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In re Application of:

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For: ELECTRICALLY-CHARGED PARTICLE ENERGY ANALYSERS

PENDING CLAIMS AFTER ENTRY OF PRELIMINARY AMENDMENT

1. A charged particle energy analyser arranged to analyse charged particles having a range of energies, comprising:

electrostatic focusing means including inner and outer field defining means extending about an axis of the electrostatic focussing means over a predetermined range in azimuth,

a charged particle source for directing said charged particles into an electrostatic focusing field generated, in use, by said electrostatic focusing means between said inner and outer field defining means, and

detection means positioned to receive and detect charged particles focused by said electrostatic focusing means,

wherein said electrostatic focusing field is defined by equipotentials which extend about said axis and which vary substantially linearly in the direction of said axis and which vary substantially logarithmically in the radial direction orthogonal to said axis,

whereby charged particles having different energies are brought to a focus by the electrostatic focussing field at different discrete positions on a surface of the detection means.

2. An analyser as claimed in claim 1 wherein said surface of said detection means is transverse to said axis.

3. An analyser as claimed in claim 2 wherein said surface is orthogonal to said axis.

4. An analyser as claimed in claim 2 wherein said surface is planar.

5. An analyser as claimed in claim 2 wherein said surface is curved.

6. An analyser as claimed in claim 5 wherein said surface is conical.

7. An analyser as claimed in claim 2 wherein said surface is in a field-free region beyond the electrostatic focusing field.

8. An analyser as claimed in claim 1 wherein said charged particles having different energies are brought to a focus by the electrostatic focusing field at different discrete positions that are spaced apart from each other in the axial direction.

9. A charged particle energy analyser as claimed in claim 1

wherein said charged particle source directs said charged particles into said electrostatic focussing field over a predetermined angular range in elevation relative to said axis,

and said predetermined angular range in elevation and/or the axial position of the charged particle source and/or the axial position of the electrostatic focusing field are set or adjustable for second-order focussing of the charged particles.

10. An analyser as claimed in claim 1 wherein said equipotentials are symmetrical about said axis.

11. An analyser as claimed in claim 1 wherein said outer field defining means is maintained, in use, at a potential relative to said inner field defining means.

12. An analyser as claimed in claim 1 wherein said inner field defining means and said outer field defining means comprise an inner cylinder and an outer cylinder respectively, wherein said inner cylinder is maintained, in use, at a uniform potential and said outer cylinder is maintained, in use, at potential varying monotonically in the axial direction.

13. An analyser as claimed in claim 12 wherein said potential varies linearly in the axial direction.

14. An analyser as claimed in claim 13 wherein said outer cylinder is made from electrically resistive material.

15. An analyser as claimed in claim 11 wherein said outer field defining means comprises a plurality of discrete field defining elements, each said element being maintained, in use, at a different respective potential with respect to said inner field defining means.

16. An analyser as claimed in claim 15 wherein each said field defining element has the form of a ring or hoop.

17. An analyser as claimed in claim 15 wherein each said field defining element has the form of a hollow, truncated cone.

18. An analyser as claimed in claim 11 wherein said outer field defining means comprises a plurality of discrete field defining elements each being made from electrically resistive material and being maintained, in use, at a respective potential which increases monotonically in the axial direction.

19. An analyser as claimed in claim 18 wherein each said element has the form of a cylinder.

20. An analyser as claimed in claim 18 wherein each said element has the form of a hollow, truncated cone.

21. An analyser as claimed in claim 1 including first and second end elements located at opposite ends of said inner and outer field defining means in respective planes orthogonal to said axis, each of said first and second end elements being maintained in use at a potential relative to said inner field defining means which varies logarithmically in the radial direction.

22. An analyser as claimed in claim 21 wherein each said end element is made from electrically resistive material.

23. An analyser as claimed in claim 21 wherein each said end element comprises a plurality of concentric electrically conductive rings each being maintained, in use, at a different respective potential.

24. An analyser as claimed in claim 21 wherein charged particles having different energies are brought to a focus by the electrostatic focusing field at different respective discrete positions in the plane of one of said first and second end elements.

25. An analyser as claimed in claim 1 wherein said electrostatic focusing means is so configured that the distribution of potential in said electrostatic focusing field is uniform as a function of azimuthal angle about said axis.

26. An analyser as claimed in claim 1 wherein said electrostatic focusing means is so configured that the distribution of potential in said electrostatic focusing field has n-fold rotational symmetry about said axis, where n is an integer.

27. An analyser as claimed in claim 11 wherein said inner field defining means and/or said outer field defining means has n-fold rotational symmetry about said axis, where n is an integer.

28. An analyser as claimed in claim 27 wherein said inner field defining means comprises a plurality of fiat side surfaces having n-fold rotational symmetry about said axis, where n is the number of said surfaces.

29. An analyser as claimed in claim 28 wherein said charged particles are brought to a focus at discrete positions spaced apart from each other along one or more of said side surfaces and said surface of said detection means is located at said one or more side surfaces to detect the focused charged particles.

30. An analyser as claimed in claim 1 wherein said charged particles are brought to a focus at discrete positions spaced apart from each other along said inner field defining means and said surface of said detection means is located at and conforms to said inner field defining means to detect the focused charged particles.

31. An analyser as claimed in claim 1 wherein said charged particles are brought to a focus at said axis and said surface of said detection means is located on said axis to detect the focused charged particles.

32. An analyser as claimed in claim 1 wherein said charged particle source is located on said axis.

33. An analyser as claimed in claim 32 wherein said charged particle source comprises a target located on said axis and means for directing radiation onto said target whereby to generate said charged particles.

34. An analyser as claimed in claim 1 wherein said charged particle source comprises a target located on said axis and means for directing radiation onto said target whereby to generate said charged particles, said target and said means for directing radiation being located within said inner field defining means.

35. An analyser as claimed in claim 33 wherein said means for directing radiation is an electron gun.

36. An analyser as claimed in claim 1 wherein said charged particle source directs charged particles into said electrostatic focusing field over a predetermined angular range in azimuth about said axis.

37. An analyser as claimed in claim 36 wherein said charged particle source directs said charged particles into said electrostatic focusing field over the entire (360°) angular range in azimuth.

38. An analyser as claimed in claim 1 wherein said charged particle source directs charged particles into said electrostatic focusing field over two or more discrete angular ranges in azimuth about said axis.

39. An analyser as claimed in claim 1 wherein said charged particle source directs charged particles into said electrostatic focusing field over one or more predetermined angular range in azimuth about said axis, said charged particles being admitted to the electrostatic focusing field by one or more windows in the inner field defining means.

40. An analyser as claimed in claim 39 wherein the or each said window has the form of an electrically conductive grid or mesh.

41. An analyser as claimed in claim 1 wherein said charged particle source directs charged particles into said electrostatic focusing field over two or more predetermined angular range in azimuth about said axis, and said detection means is so configured and arranged as to detect charged particles derived from each said angular range.

42. An analyser as claimed in claim 1 wherein said detection means comprises one or more detector selected from a multi channel array detector, a microsphere array detector and a position-sensitive resistive plate detector.

43. An analyser as claimed in claim 42 wherein said one or more detector incorporates a phosphor-coated detection plate.

44. An analyser as claimed in claim 1 including means for adjusting the axial position of said charged particle source.

45. An analyser as claimed in claim 11 including means for adjusting said potential whereby to vary the axial position of the electrostatic focusing field relative to said charged particle source.

46. An analyser as claimed in claim 1 wherein said charged particle source includes aperture means for directing charged particles into said electrostatic focusing field over a predetermined angular range in elevation relative to said axis.

47. An analyser as claimed in claim 46 wherein said predetermined angular range in elevation and/or the axial position of said charged particle source and/or the axial position of the electrostatic focusing field are set or adjustable for second-order focusing of charged particles.

48. An analyser as claimed in claim 1 wherein said charged particle source directs said charged particles from a location or locations offset from said axis.

49. An analyser as claimed in claim 48 wherein said charged particle source includes means for focusing charged particles at said location or locations.

50. An analyser as claimed in claim 1 wherein said charged particle source and said detection means are both located between said axis and said inner field defining means.

51. An analyser as claimed in claim 1 wherein said charged particles are brought to a focus at discrete positions spaced apart from each other along said inner field defining means and said detection means comprises a detector located radially inwards or radially outwards of the inner field defining means and means for focusing said focused charged particles onto said surface of said detector.

52. An analyser as claimed in claim 1 wherein said charged particle source includes a real source located at a first position and means for focussing charged particles produced by said real source at a second position different from said first position whereby said charged particle source creates a virtual source at said second position from where said charged particles are directed into said electrostatic focussing field.

53. An analyser as claimed in claim 1 wherein said outer field defining means comprises a curved plate having rotational symmetry about said axis.

54. An analyser as claimed in claim 53 wherein said curved plate is maintained at a uniform potential.

55. An analyser as claimed in claim 24 wherein said one element is maintained at zero potential.

56. A method for operating a charged particle energy analyser as claimed in claim 1 comprising the steps of applying voltage to said electrostatic focusing means in order to obtain operation in the first-order focusing mode within a predetermined energy range and scaling the applied voltage in order to obtain operation in the second-order focusing mode at a selected narrower energy range within said predetermined energy range.

57. An analyser as claimed in claim 1 wherein said predetermined range in azimuth is the entire (360°) azimuthal range.

58. An analyser as claimed in claim 1 wherein said inner and outer field defining means comprises an inner cylindrical segment and an outer cylindrical segment respectively, wherein said inner and outer cylindrical segments extend over a predetermined angular range in azimuth and said outer cylindrical segment is maintained, in use, at a potential varying linearly in the axial direction.

59. An analyser as claimed in claim 58 wherein the longitudinal side edges of the inner and outer cylindrical segments are joined by side walls.

60. An analyser as claimed in claim 59 wherein said side walls are adapted to define a predetermined potential distribution over their inward facing surfaces.